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SUMMARY REPORT: WORKSHOP ON VEHICLE TECHNOLOGIES TO AID TEEN DRIVERS

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1.0 Workshop Problem and Objectives

The focus of this workshop was to explore ways to reduce teenage driver fatalities and injuries by using vehicle-based technologies to detect and report unsafe driving behaviors. In various implementations, such systems could be used by parents and their teenage children, by driver education programs, by DMVs, law enforcement agencies, or by the court system. For the purposes of this workshop, the term “Teen Driver Electronic Report Card” (TDERC) was used to describe such monitoring systems (Note: the program name has been changed recently to “Electronic Copilot for Teen Drivers, eCTD) . A brief introduction to the concept was given in the workshop announcement:

Traffic crashes continue to be the number one killer of teenagers. Traditional traffic safety initiatives (e.g., licensing, enforcement, and education) have improved safety, but achieving even greater reductions in fatalities and injuries may require innovative new approaches to further increase safe driving practices among teens. One promising approach is to use advanced, vehicle-based technologies that can operate in real time to sense, record, present, or transmit information on unsafe driving behaviors. These technologies can be integrated into a safety device that functions as a “Teenage Driver Electronic Report Card” (TDERC) on safe behaviors. This electronic report card would function as a learning tool and motivator to help teens identify and improve their unsafe actions. To implement an acceptable and effective TDERC, a systematic research program is needed. The research needed to develop, implement, and evaluate a TDERC will be the focus of this workshop. (From the Workshop Announcement, see Appendix A.)

The objective of the workshop was to identify the viewpoints of stakeholders and researchers about:

- The degree to which the teen crash problem can be addressed by a TDERC.
- Technical feasibility of a TDERC.
- Deployment of TDERC in the real world, including the role of private sector and public institutions.
- Factors influencing effectiveness, acceptance, and feasibility of TDERC programs.
- Research needs and methods.

The workshop was organized by Michael Perel (National Highway Traffic Safety Administration).

2.0 Workshop Structure

Participants were invited to attend the workshop based on their expertise, interest, and previous work in areas related to teenage driver safety. Among the participants were experts on teen behavior, vehicle technologies, law enforcement, insurance programs, driver education, crash statistics, and research methods. The list of participants is given in Appendix B. A goal was to bring together experts from several different disciplines that could contribute to the discussion of

TDERC from different perspectives. Several workshop materials were sent to participants to review prior to the meeting in Washington, DC. These materials are included in Appendix A.

The workshop was conducted at ITS America offices in Washington, DC, on November 4, 2004. An overview of the TDERC concept and the final agenda for the workshop can be found in Michael Perel's presentation in Appendix C.

3.0 Summary of Presentations and Discussions

This section summarizes the presentations and comments made by workshop participants during the meeting. Michael Perel moderated the discussion. The comments reported here are not direct quotations from individual participants. They have been reproduced from notes taken during the meeting and from accounts of workshop participants. Many of the descriptions below are simply summaries of the main discussion points. There has been no attempt to identify the speaker of any individual comment, and the comments reported do not necessarily reflect a consensus opinion.

3.1 Teen Driver Crash Problem

Dr. James McKnight (Transportation Research Associates) presented data from a retrospective study of errors made by teen drivers involved in crashes. Slides from his presentation are shown in Appendix D. One-third of the 2,100 crashes in the study sample resulted in injury or death (0.5% fatalities), while the remaining crashes resulted in property damage only (PDO). Dr. McKnight observed that the proportion of fatal crashes is small compared to all teen crashes, that fatal crashes are primarily speed-related, and that these crashes may involve the so-called "reckless" teens, who may be difficult to reach with any type of intervention. He recommended that the focus of study for a TDERC program should be on the injury-causing and PDO crashes, because if we do this, all teens may benefit from the program. A theme which emerged from the presentation was that crashes involving teen drivers, especially in the first 1,000 miles of driving, are primarily due to errors related to inexperience with driving, rather than to age-related factors; the primary evidence being that there is a two-thirds reduction in the crash rate for teens after the first 1,000 miles of driving. Dr. McKnight concluded that teen driver crashes are caused by mistakes, which are often due to inexperience, and that teens often don't recognize the danger of the driving situation. He indicated that an important question is how to prepare teens to recognize driving hazards in the environment. In the discussion, which followed, some participants cautioned that we shouldn't put too much emphasis on inexperience as the most important factor in teen crashes. Most participants agreed with the statement that in the United States, age-related factors and inexperience contribute equally to the high crash rate for teen drivers.

Dr. Tom Dingus (VTTI) presented data, including video clips, from the 100-Car Study of instrumented vehicles, conducted by Virginia Tech Transportation Institute. This study shows the feasibility of recording many parameters of vehicle dynamics and vehicle control, position of the vehicle in relation to the roadway, and in relation to other vehicles. Five onboard video cameras capture the driver's glance directions and behavior as well as external events occurring in front of and around the vehicle. Together these systems provide a record of normal driving and allow deviations from normal driving to be identified from sensors, for example, from events of high lateral or longitudinal acceleration. Although no drivers under the age of 18 were included in this study, Dr. Dingus pointed out that the youngest age group (18-20 years old) of drivers (n = 16) had higher numbers of abnormal events as compared to older drivers, and that many episodes of distracted driving (attending to other tasks besides driving) were observed in this group. Dr. Dingus was optimistic that the capability to monitor just about any driving behavior would be possible to develop. In the discussion that followed, it was suggested that obtaining naturalistic driving data for young teens may provide answers about what parameters to measure and when to monitor teen driving behavior. There was some discussion about the naturalness of the behaviors observed in the 100-Car Study, because the drivers knew that they were being recorded. Dr. Dingus responded that the drivers in the study seemed to habituate to the devices on the vehicle very quickly, and that he was convinced that the behaviors recorded were quite natural. A question was raised as to the effectiveness of monitoring devices in a TDERC system, in reducing risky behavior, if drivers habituate to the devices, as in the 100-Car Study. It was pointed out that a key difference with proposed TDERC concepts is that there would be feedback to the driver (and drivers' parents or others).

Discussion on Teen Driver Safety

The discussion on teen driver safety included an attempt to define more clearly which population of drivers is to be targeted by a TDERC program, and which types of crashes are to be targeted. Young (16-17 years old), novice drivers were defined as the target group. There were some differences of opinion about whether to focus on fatal crashes. The following points were made: one person thought that the system should focus on crashes in general and could reduce fatal crashes, too. Another participant thought that the "hard-core" offenders are harder to address, and that they may be addressed by later versions of a TDERC system. One person stated that finding ways to reduce PDO crashes is not important unless it is predictive of more serious crashes. Some participants felt that fatal and non-fatal crashes have the same root causes, but that the different outcomes are due to the circumstances. For example, a run-off-the-road event may be fatal if a tree happens to be in the vehicle's path. In later discussions, it was stated that we should distinguish between the behavioral problems associated with crashes in the first 1,000 miles from those occurring later. The belief expressed was that the most pressing issues in the first 1,000 miles may not be aggressive driving, lack of safety belt use, or lack of cognitive ability.

The following question was addressed to all participants, "What is unique about teen crashes?" One view was summarized by saying that teen drivers are the same as adult drivers, but with a lack of experience. Another participant pointed out that early naturalistic driving data suggests that distraction is a key factor for young drivers, who as a group seem more willing than older drivers to engage in secondary tasks while driving. One participant summarized the primary contributing factors to fatal crashes for teens as: excessive speed, inattention, driving on the wrong side of the road, failure to yield, and running off the road (and subsequent over-corrections in steering). A discussion of countermeasures for running off the road included the observation that insight is needed into what behaviors lead to running off the road.

The discussion focused on the question of teen behavior, with the goal of modifying undesirable behaviors. Several generalizations about teen behavior were mentioned, with the caveat that not all teens show all of these characteristics:

- Teens tend to be egocentric "performers" who adjust their behavior to the audience present. This may explain why having teen passengers contributes to the crash risk. The discussion moved to the effectiveness of the TDERC and whether teens' behaviors would be modified by having a monitoring system present. Several participants gave examples or commented on the importance of the link between monitoring and feedback. For example, monitoring of location and speed in police patrol cars reduced crashes for a period of time, but when it was determined that this information would not be used for disciplinary action, the crash rate increased again. Another example addressed the concern that teens may forget that the monitoring technology is in the vehicle and fail to be influenced by it. Although teens may initially try to act properly when a driving instructor is present, they quickly revert to bad driving habits which are easily detected by an instructor.

- Teens have a peer-orientation. They are sensitive to being evaluated by friends and family. They may take risks to show off.

- Teens tend to be motivated by sensation seeking. They enjoy the feeling of going fast, and enjoy taking risks, even without an audience present.

- Teens perceive less risk than do adults in the same situation. Teens do not always appreciate the potential danger of driving situations, and may be in more crashes because they don't take risks seriously.

- Teens have an optimistic bias concerning their driving abilities. They think that they are skillful drivers. In fact, teens do have fast reaction times, detect other vehicles faster, and judge speed more accurately than older people. However, while vehicle handling skills are built quickly, perceptual skills in driving may not be developed without a lot of experience. An example was given to support the view that greater skill can sometimes be an indicator of a higher crash rate. Amateur race drivers have a higher crash rate than the general population.

- Teens have a need for independence. They have growing capabilities for autonomy and self-sufficiency. They value cars because no one can monitor them. They may have a different life, of which parents are not aware, that is centered on their vehicle.

- It seems likely that safety-conscious parents would be the "early adopters" on behalf of their teenage drivers. This would in turn eliminate a large group of teens who could also benefit from the technology. Because of this, early voluntary deployment of devices might not demonstrate discernable behavioral improvements. Device deployment might have to be widespread in order to have demonstrated effectiveness.

- Parents express concern that a monitoring device would threaten the trust within the parent-teen dyad. It was thought that transferring the burden to other institutions or authority figures would lessen the intrusion.

Attitude and maturity, which are contributors to the teen crash problem, may be difficult to measure, difficult to correct with technology, and may determine whether a TDERC system would be accepted. On the other hand, if a TDERC system is very effective in reducing risky driving behaviors, then the driver's attitude may be less relevant.

The concept of "driving intensity" – the overall style of driving, was discussed. Naturalistic data shows that some drivers always accelerate, brake, and corner harder than other drivers. Also, different vehicles will have different characteristics (weight, handling, etc.), and the TDERC system would need to take these differences into account. There may be a need to define either individual or group norms for certain driving parameters as well as defining unacceptable levels of deviation from these norms.

3.2 Measures and Technical Feasibility

Dr. Max Donath's (University of Minnesota) presentation on technological options for implementing the TDERC concept (see Appendix E) focused on how technology could be used in three different ways by:

- Forcing behavior – vehicle operation requires specific desirable behaviors to occur (wearing seatbelt), or prevents undesirable behavior (speeding).

- Providing driver feedback – real time warnings to alert the driver about poor driving and other potential risks.

- Reporting behavior – various measures (including video) of vehicle dynamics, and location can be saved for inspection by parents or other authorities.

Dr. Donath discussed lack of safety belt use, alcohol use, and excessive speed as three areas where drivers' risky behaviors could be controlled with technologies such as interlocks and intelligent speed adaptation (ISA) systems.

Several technological issues were identified for existing, near-term, and future systems. For example, driver feedback about speed should be context sensitive, but there is no database of local speed limits currently available. Future systems with context sensitivity eventually could be extended to include weather, roadway conditions, and traffic conditions, and predictions of road curvature.

Headway monitoring requires extensive use of radar or lidar technologies, which are currently being used in adaptive cruise control systems. Lane position monitoring may be achieved with image processing or a combination of sophisticated GPS technologies and a database of digitized roadways, although these technologies may be too costly in the near-term to be used for a dedicated system to monitor teen drivers.

Some human factors issues were identified in the area of speed control. ISA systems, which restrict speed, may have unintended behavioral consequences. Some data suggest that drivers whose speed is regulated by an ISA system may try to compensate for "lost time" by accepting shorter gaps in cross traffic flow, and by maintaining closer following distances. Another potential problem is complacency, and over-reliance on the system. Drivers who use ISA systems with mandatory, fixed limits on speed may tend to drive near that fixed limit even when conditions dictate a lower speed to be safe.

Dr. Donath reviewed the capabilities and limitations of several driver monitoring devices that are currently available to consumers. Some of these devices are passive devices that read data from the OBD-II port (available on many vehicles manufactured after 1996). Some provide auditory feedback to the driver, and others provide real-time notification of parents through a cellular telephone call. The communication capability of cell phone networks was mentioned as a possible solution for wireless access to vehicles. Another system reviewed stores video clips from forward-facing and rearward-facing cameras for a short period of time immediately preceding and immediately following any event in which sensors detect excessive lateral or longitudinal acceleration of the vehicle. The systems reviewed had significant limitations, including inability to identify the driver of the vehicle or number of passengers, lack of clear user interface, difficulty for parents to review data from the device or understand reports, inability to modify speed thresholds based on local speed limits, prevailing traffic conditions, weather, pavement conditions, or local roadway geometry. None of the systems reviewed included any forcing functions.

Research needs and other issues identified in the discussion surrounding this presentation are incorporated into the sections below.

3.3 Deployment Issues and Options

- Marketing needs may dictate whether the focus of a TDERC program is on fatal crashes versus less severe crashes. Getting people to purchase and use the technology may require additional features, such as theft deterrence.

- The driver interface cannot increase distraction and needs to have a perfectly clear message.

- When developing hardware, it is important to keep in mind that mass-production reduces prices, so it may be possible to make a more advanced device earlier and with less cost.

- Would insurance incentives be adequate to mitigate the potential extra liability/exposure to parents that may come with having documented evidence of their teen's bad driving behavior?

- An important issue regarding implementation is determining who is in the vehicle. Teen drivers may not have their own vehicle, but may use other family vehicles. "Smart Key" technology could be used to restrict monitoring to certain drivers (key holders). Detecting the number of passengers is also of interest, but video cameras may be perceived as being too intrusive, creating privacy concerns.

- An implementation concept involving "Smart Key" technology is to marry intelligent key data storage capability with parent/teen driving contracts or graduated licensing programs. Teen drivers could be required to demonstrate a certain number of hours/miles of safe driving behavior, which would be linked to the teen driver's Smart Key.

- Would TDERC systems be implemented as an OEM device or sold as an aftermarket product? Without standards, aftermarket product developers may face difficulties accessing vehicle data.

- What features of any proposed TDERC system would be unique for teens? How would other advanced vehicle systems such as adaptive cruise control and collision warning systems interact with a teen driver system?

- How will local data be put into the system (e.g. statutory speed limit guidelines based on road type for each State)? These will be limited, and often won't correspond to local posted speed limits.

<u>New name needed for system to monitor teenage drivers</u>

One participant strongly recommended that a new name for the TDERC concept should be developed because teen drivers would not like what the name implies, i.e., the need to be monitored and then evaluated. This is because report cards generally have very negative connotations for teenage students, and because people who are in their mid to late teen years may prefer to think of themselves as young adults rather than teens. For them, the word "teen" may have negative associations based on the large number of "teen" products that are marketed to younger teenagers. The following names were suggested by participants:

- "Young Adult Safety Promotion System"

- "Teen and Young Adult Safety System"

- "Electronic Driver Improvement Module"

Other considerations for finding a suitable name were discussed:

- Five to ten possible names should be developed and then tested in focus groups.

- Need to consider naming from a marketing perspective to teens and parents, but the name should also make sense in terms of NHTSA program objectives. Perhaps two names could be used – one for marketing purposes, and one for the program overall.

- How the system is going to be implemented should be factored into the name. Specifically, what will be the roles of States and GDL programs?

- Acceptance of the concepts should be formally evaluated, and then this can guide the name.

- Teen organizations such as Students Against Drunk Driving (SADD) and other groups may be solicited for advice about names.

<u>Program Implementation Models</u>

- Legislation would be required for any system to be implemented as part of a GDL program, but obtaining legislature buy-in may be very difficult.

- One legal requirement for implementing any sanctions is to prove that the suspected violator was the person behind the wheel when the violation occurred. A technical solution to this problem may be to use a smart key, plus a driver camera. This solution would increase costs (hardware, data storage capacity, etc.).

Court-ordered TDERC: Discussion focused on implementing a court-ordered TDERC program for those teens who have already been cited for violations.

- This has the potential to be a great intervention; however, the lack of standard laws, especially GDL laws, makes developing a program difficult because each State would have to customize the program.

- Currently, GDL violators have an incentive to plead not guilty because they are typically scheduled to be out of the GDL system by the time of their trial.

- People tend to have crashes before they have been cited for violations.

- Due to the current structure and high workload in traffic court, buy-in from judges may be difficult. Many judges are now already reluctant to give points or other sanctions because evidence must be taken, and this takes too much time in court. In one jurisdiction, after multiple teen fatalities, police had to increase ticket writing for judges to take the problem more seriously.

- Can TDERC technology be developed to stand up in court as evidence? Judges are never the first to make decisions, but if using the technology starts voluntarily, perhaps with the help of insurance incentives for motivation, judges will be more accepting of it overall.

Department of Motor Vehicles model: In another proposed program model, DMVs would administer a TDERC program themselves, outside of the court system. For example, many DMVs currently have authority to extend GDL requirements, but usually not past age 18. Some States may be able to impose restrictions past age 18. Any additional authority and responsibility for DMVs would require legislation.

- If TDERC technology were implemented as part of DMV oversight, a mileage requirement could be instituted as the basis for advancement through the GDL license stages (mileage would be recorded objectively by an in-vehicle system). Teens would have to sign off on the mileage (driving data) to verify that they were the driver. Forcing teens to prove that they have the required experience may keep them in the GDL program longer. One participant noted that anything that increases the length of time that a new driver is under GDL restrictions will have a safety benefit.

- Assuming that teen driving data is damaging, parents' knowledge of it would put them at greater liability risk. Parents may need incentives in order to accept this greater legal risk. Insurance companies would also face liability issues if they had access to individual drivers' data. There may be legal questions for DMVs having monitoring data as well.

- DMVs may not like the ideas being discussed here. Current GDLs are simply a license restriction, not a monitoring program. Adding the TDERC program would require many more person-hours at the DMV, which will increase their costs. DMVs would need additional funding from the program to get their acceptance. Also, under the proposed model, DMVs would be responsible for putting extra restrictions on teens and this may degrade the DMV image. This is another possible reason why DMVs may be reluctant to take on the TDERC program.

- One suggestion to limit liability issues for DMVs would be to have a contract with the parent, saying that they will review the monitoring data with their young driver, (but not send it to the DMV). The parents' accountability may be enough to deter bad driving behaviors.

Funding of TDERC program: The costs of operating a TDERC program (either DMV-based or court-based) could be violator-funded by those (e.g., speeders, DWI) who must pay fines. These fines could have an add-on fee imposed that would fund the TDERC program.

- Some jurisdictions already have so many add-on fees to traffic tickets that police officers are hesitant to write citations for minor violations. Some States take out a percentage of fines to fund certain programs rather than listing add-ons, in this way the offender doesn't know where the money is going.

Driver education programs: The use of TDERC systems in driver education programs was discussed.

- Driver education professionals believe that young driver monitoring would be effective; however, parents generally do not want to spend more money in the licensing process of their teens, especially if they are already paying for professional driving instruction.

- Driver education instructors would benefit greatly from a printout with actual driving data for trips taken when the teen is not in class.

Insurance incentives: Insurance industry involvement in TDERC implementation was discussed.

- Insurance companies now give discounts for teen drivers from existing covered families who are already good risks. A motivation for insurance companies is to attract better (good risk) drivers. Perhaps those who choose to use TDERC systems would be better risk drivers.

- Insurance companies would not want to receive actual driving data, as this would cause legal liability problems for them if there were aware of an individual's risky driving behavior.

- Insurance companies would need actuarial data. They would need data collected over time to determine if the costs saved by using TDERC systems would justify additional discounts. Definitive data may take 10 years to acquire.

- The insurance industry would be interested in research from TDERC studies that show how to predict who is a risky driver, and may then use that information as a filter for potential customers.

- The insurance industry would like to know whether reducing risky behaviors reduces crashes. Perhaps government and industry could work together to provide the research required to answer this question.

DWI offenders used for system evaluation: A novel approach for developing and testing the implementation of TDERC systems was suggested. DWI offenders could be required to (or choose to as an alternative to losing their driver's license) use driver behavior monitoring equipment. Although DWI drivers may have different driving behaviors than teen drivers, the following benefits of this model were discussed:

- As a first step for TDERC, this might be relatively easy to implement because feedback to DMVs would work the same way as the current monitoring of alcohol interlock devices.

- This would be a way to get public exposure and acceptance of the technology.

- It provides a test of whether DMVs can assume the new tasks that would be involved with such a system.

- It provides an opportunity to do a large-scale field test, and work out any technological problems.

Although this model might be effective for working through various deployment issues with driver monitoring systems, some workshop participants questioned the logic of using DWI drivers as surrogates for novice drivers. For example, the driving behaviors, acceptance level, and nature of the feedback provided might be very different for these groups.

High School implementation model: The idea of using TDERC systems for high school students who drive to school was discussed. This model could be used initially for system evaluation purposes. High schools may make the device a prerequisite for parking in the student parking lot.

- The needs for this model would include a cooperative school district and high schools that have limited student parking. Schools will differ in the amount of student parking available, but in some schools, the parking benefit could be the motivation for students to participate.

- A possible motivation for school districts is to get kids with licenses out of school buses in order to reduce overcrowding on buses or reduce the number of buses needed. The approach described above may work against this goal, if participation in a TDERC program presents a barrier to students driving themselves to school.

<u>Privacy concerns with TDERC</u>

There was a brief discussion of privacy concerns related to TDERC.

- Legally, there are no privacy issues for children under 18. Implementation problems are more related to acceptance of the system and how it would be used by teens and their parents.

- A system that uses only interlocks or other ways to force behavior without reporting or storing data would not have any privacy issues.

- Systems that keep records have the potential to violate privacy.

- The “reasonable expectation of privacy” may be limited or may not apply if drivers are fully informed that they are being monitored.

3.4 Federal Role

Provide Research Funding

- Fund research to develop an improved monitoring system that is better than those currently on the market.

- NHTSA could promote research on teen drivers by requiring or encouraging researchers to include teen driver groups in applicable research projects. A better understanding of teen driver behavior could lead to more effective designs for TDERC systems.

- Applied research is needed to quantify possible safety benefits and acceptance of TDERC systems.

- The ITS research model could be implemented for TDERC, where the Federal government funds fundamental research, and then the automotive industry continues with research and product development.

- If federally sponsored research demonstrates a safety potential, then the technology may be accepted and adopted by other users (e.g., school systems, courts, rental car companies, employers).

Provide Enabling Technology and Data Resources

- Support development of enabling technologies. One example is the need for certain in-vehicle data, such as enhanced map data on speeds. Perhaps an online database of speed limits could be established. Industry is not likely to do it themselves due to the lack of incentive to work together. They need the Federal Government to enforce standards and provide incentives. Having local roadway data available may allow industry to offer products that are not possible now. (There is a need to show that making such data available will have a direct impact on product development.)

- There may be a possible Federal role in promoting the collection and sharing of driving data recorded by monitoring systems. If data elements of monitoring systems were standardized, target groups of drivers/researchers could donate their driving data to a large database.

Standards

- Standards development is needed to encourage commonality of vehicle data and connectivity that could be used by aftermarket devices.

- NHTSA could maintain a list of approved devices, similar to alcohol breath testing devices and develop minimum standards for device capabilities. This will lead to acceptance of devices by courts and by the public.

Advocacy, Model Legislation, and Providing Incentives

- Accelerate development of the teen driver monitoring concept through research and working with stakeholders.
- Inform legislatures of the value of these systems (if there is evidence) and provide information on possible model legislation.
- Provide incentives to States through DOT funding. Examples were cited of the Federal Government restricting funding to States based on maximum speed limits and laws concerning blood alcohol concentration of drivers.

3.5 Research Questions Identified During Workshop

Driving Behaviors

- What are the relative contributions of aggressive driving versus inexperience of teen drivers that increases their crash rate?
- For teens driving under natural conditions, how do various sources of driver distraction and social factors (passengers) influence driving behaviors?
- What skills, knowledge, and perceptions are attained in the first 1,000 miles that cause such a drastic decrease in crashes?

Measures of Unsafe Driving

- What are the “magic parameters” that need to be monitored to reduce crashes? Which surrogates are appropriate to define “good driving”? For example, is hands-on-the-wheel an accurate measure for willingness to multitask or engage in distracting behaviors? What is the optimal feedback algorithm for predictors of an impending crash, or for indicators of a propensity to be in a crash in the future?
- Can safety problems be reliably and accurately detected electronically without roadway/traffic contextual information?
- What is the role of general deterrence? Can recording some specific behaviors influence how carefully novice drivers attend to the driving task in general? Do current devices on the market provide a general deterrence effect?

Feedback and Reporting

- How should data best be used to influence behavior? Should reporting be based on discrete events or should it be based on some measure of average driving intensity (or overall driving performance)?

- What type of in-vehicle feedback signals (auditory, visual, etc.) should be used to provide feedback to the driver? They should be considered in the context of other in-vehicle systems.

- How often do teen drivers need to be reminded that the system is monitoring their behavior for it to be effective?

- How do different forms of monitoring (video versus numeric data; immediate versus delayed feedback) affect teen driver behavior?

- How do different consequences of monitoring affect teen behavior? Should the feedback go to teen, parent, others?

- What is the best way to administer feedback? One person suggested that a system that reports only bad behavior may not be as effective as one which also rewards good behavior. How should the system handle improved driving? Should there be a positive component to feedback?

- Usability of the TDERC system for parents is an issue. How much data (and effort required to review it) would parents be willing to accept and find useful? Could the system automatically provide an assessment/interpretation of the teens driving – to reduce the burden on the parents to interpret the performance results and reduce confusion?

<u>Safety Benefits</u>

- Does increasing safe behavior by teen drivers reduce crashes? Will a TDERC system to monitor teen driver behavior actually improve safety?

- Would monitoring for a short period (1,000 miles) have a net safety benefit or would it displace risk, i.e. would people just crash later, after they are no longer monitored?

- Will exposure to a monitoring and feedback system for 16- to 17-year-old drivers have safety benefits that will carry over to latter ages?

- Are there any unintended consequences of teen driver monitoring which may reduce safety benefits? For example, there is evidence that drivers who have vehicle speed restricted by intelligent speed adaptation (ISA) systems may compensate by accepting shorter gaps in crossing traffic and closer following distances. Another potential problem is “automation complacency”, the tendency to place too much reliance on the monitoring system to ensure safe driving behavior.

<u>Motivation and Acceptance</u>

- How acceptable would various implementation models and incentives (e.g. DMV-based, school-based, insurance discounts, etc.) be to parents and teens?
- What forms of technology (such as interlocks, real-time feedback, reporting systems) would be acceptable to parents and teens?
- What level of privacy and monitoring would be acceptable to teens and parents? How would video (and/or audio) recordings impact the overall level of acceptance?
- What level of parental involvement (time spent reviewing data, counseling teen driver, etc.) would be acceptable?
- In the case of shared family vehicles, would it be acceptable to monitor parents as well as teens?
- Are there other features not specific to teen driver safety, such as vehicle theft deterrence that would enhance the acceptability of TDERC systems?
- What price points for factory-installed or aftermarket driver monitoring technologies would be acceptable to teens and parents?
- How do parents value the potential safety benefits of teen driver monitoring compared to their desire to have their child become an independent driver, free of GDL or other restrictions?

4.0 Conclusion

At the end of the workshop the following conclusions were discussed.

<u>TDERC Potential to Reduce the Teen Driver Crash Problem</u>
There was general consensus that TDERC systems could potentially be valuable and that a teen driver monitoring initiative would be worth implementing. TDERC systems have the potential to reduce the crash rate for young drivers, although the size of the safety benefit is to be determined.

<u>Technical Feasibility of TDERC</u>
TDERC systems are technically feasible now, but current products on the market need to be improved. Systems that are very different than current products may be needed.

<u>Implementation of TDERC Programs</u>
Implementation of TDERC programs requires more research, which could be done in parallel to basic research on behavior and technology.

<u>Federal Role</u>
The Federal role could include funding research to collect naturalistic driving data on the appropriate age group, develop improved monitoring systems, evaluate existing systems, develop minimum standards for devices, create a list of “approved devices,” promote enabling technologies, support standards for commonality of vehicle data and connectivity, inform legislators of the value

of these systems (if proven), provide possible model legislation, and accelerate development of the concept through research and by working with stakeholders.

Research Needs

Research needs include determining which behaviors to monitor and which implementation models are most feasible and likely to succeed. Many other specific research questions are listed above.

Appendix A: Workshop Materials

A1: Workshop Announcement

Teenage Driver Electronic Report Card (TDERC) Workshop

Vision

Traffic crashes continue to be the number one killer of teenagers. Traditional traffic safety initiatives (e.g., licensing, enforcement, and education) have improved safety, but achieving even greater reductions in fatalities and injuries may require innovative new approaches to further increase safe driving practices among teens. One promising approach is to use advanced, vehicle-based technologies that can operate in real time to sense, record, present, or transmit information on unsafe driving behaviors. These technologies can be integrated into a safety device that functions as a "Teenage Driver Electronic Report Card" (TDERC) on safe behaviors. This electronic report card would function as a learning tool and motivator to help teens identify and improve their unsafe actions. To implement an acceptable and effective TDERC, a systematic research program is needed. The research needed to develop, implement, and evaluate a TDERC will be the focus of this workshop.

Workshop Format: In addition to US DOT staff, the workshop will assemble about 10-15 researchers, practitioners, and vehicle technology experts to exchange ideas and knowledge about the research effort required for development, implementation, and evaluation of a TDERC. The participants will be sent a brief description of a proposed concept for a TDERC strategic research plan and issues for discussion at the workshop. The participants will be asked to discuss their perspectives on TDERC feasibility, research needs, and research approaches. The participants will present their viewpoints at the workshop to provide a stimulus for discussions about the issues. The information and recommendations of the workshop will be summarized in a report.

Participants

Participants from the following groups will be invited:

- Federal representatives: This group will include subject matter experts on human factors research, teen crashes, driver education, licensing, and safety belt use.
- Researchers: The group will include researchers with expertise in human factors, teenage driving safety, behavior modification, and public health.
- Practitioners: This group will be comprised of people representing organizations whose knowledge, acceptance, and involvement will be critical for success of a TDERC, such as vehicle technology suppliers, driver educators, enforcement, graduated drivers licensing programs, legal representatives, and insurance companies.

Outcomes and Deliverables

Participants will discuss issues and make recommendations on the following topics.

- The teen crash causation problem that can be addressed by a TDERC
- Behavior modification techniques applicable to in-vehicle monitoring systems
- Human factors considerations in developing monitoring systems that are acceptable and effective

- The state-of-the-art of in-vehicle driver behavior monitoring technologies applicable to a TDERC
- Performance and behavioral measures to monitor
- Factors influencing acceptance—privacy, ease of use, security, incentives (e.g., insurance discounts)
- Factors influencing effectiveness—interlocks, real time monitoring, parental involvement, inclusion in driver education, inclusion in graduated licensing
- Research needs and methods
- Measures of effectiveness
- Implementation challenges

A report will be assembled that summarizes the comments and recommendations of participants. Suggestions for research directions and methodologies will be incorporated in a revised research plan to be presented to the Department of Transportation Management Council.

Date
The workshop will take place November 4, 2004, in the Washington, DC, area.

A2. Preliminary Agenda

Teenage Driver Electronic Report Card (TDERC) Workshop

DRAFT Agenda and Discussion Topics

November 4, 2004
ITS America, 1100 17th Street NW., Suite 1200, Washington, DC

Morning

Continental Breakfast: 8:15 a.m.
Welcome and Introductions: 8:45 a.m.

Background and Objectives of Workshop

The teen driver safety problem and its reduction through behavioral monitoring countermeasures (presentation)

- What unsafe behaviors do teens exhibit that contribute to crashes?
  - What is unique about teen crashes and unsafe driving behaviors?
  - How do teen safety problems and behaviors change through teen years?
- What behavioral modification principles could/should be applied to the design of a teen driving monitoring and feedback system?
  - What is unique about teen decision-making and safety behavior, teens as recipients of safety interventions?
  - What is the role of positive reinforcement for safe driving? How should it be implemented?
  - What is the role of penalties and negative consequences for unsafe driving?
  - What is the role of more direct interventions, such as interlocks to prevent starting if belts are not worn or speed limiters?
- What individual differences among teens should be considered in the design and implementation of a behavioral monitoring system – e.g., temperament, family dynamics, and cognitive/emotional health – and their impact on traffic crash involvement?
- What additional research is needed to understand the extent and nature of the teen driving safety problem with respect to developing an effective and acceptable behavioral monitoring system?

What behaviors should be monitored as part of the Teenage Driver Electronic Report Card (TDERC)?

- Discussion of the "TDERC" name for the research program
- Discussion of the row and column headings in the behavior matrix in preliminary proposal
  - Consider completeness of behavioral measures and evaluation criteria
  - Prioritize behaviors to monitor in near term versus long term TDERC

What are the technology capabilities and limitations that affect what can be monitored and what implementation options would be feasible and practical? (presentation)

- Technology overview
  - What are the technical considerations for developing and installing an aftermarket TDERC?

- What are the technical constraints involved in measuring and monitoring each type of behavioral measure?
- Considering that a vehicle may have multiple drivers, what technologies could be used to identify who is driving so that the TDERC only monitors the teenage driver?

➢ Data integrity/security
- What approaches could be taken to reduce hacking or deactivation?
- How can security been ensured while transferring data?

➢ Technology-related research needs

LUNCH (in meeting room)

Afternoon

How do different implementation options affect acceptance and effectiveness?

➢ What are the effectiveness, acceptability, and feasibility tradeoffs among options for implementing a monitoring system?
- Use as part of driver education program
- Use after driver education to reinforce safe driving behaviors during first years of driving
- Providing data to parents to help monitor driving behaviors
- Directly preventing unsafe behaviors through vehicle interlocks
- Installation in vehicles of teens receiving tickets for traffic law violations or involved in crashes
- Insurance reductions for teens demonstrating safe behaviors
- Improve and enhance graduated driver license
- Others?

➢ Legal, privacy considerations
- What are the privacy/data ownership issues between parents/teens?
- What are the privacy issues between parent/teen and outside groups?
- What are the legal limitations to requiring device as part of attaining driver’s license (e.g., as part of driver’s ed or GDL program)?
- Who could/should have access to data from a monitoring system?
- What differences are there between behavioral measures in terms of legal constraints?
- Would there be a legal obligation to stop highly unsafe or illegal behaviors detected by monitoring system, e.g.., should interlocks be required for if safety belts are not worn (versus just warning, recording data)?
- From a legal viewpoint, should the TDERC be required for all new drivers, regardless of age?

➢ Parental acceptance
- What is the best way to increase acceptability to parents?
- What additional support (e.g., training) will parents need to optimize the data in TDERC?
- At what stage of the research program should parents’ viewpoints be evaluated?

➢ Teen acceptance
- What device design and implementation approaches increase acceptability to teens?

  - What would be the impact on acceptability if “higher-risk” teens (e.g., traffic offenders) are monitored versus the entire teen population? How would this affect potential safety benefits?
  - How long should teens be required or recommended to use a TDERC?
  - At what stage of the research program should teen viewpoints be obtained?
- Cooperative arrangements (GDL, insurance, enforcement)
  - How could/should TDERC be part of Graduated Driver License (GDL) program, e.g., to add more high-risk behaviors to graduation requirements, to enhance enforcement of existing requirements?
  - With what frequency would teens have to submit information for optimum effectiveness?
  - What data are needed to support legislative changes to include unsafe behavior monitoring in GDL programs?
  - What are constraints regarding implementing a GDL using a TDERC?
  - What information would insurance companies need in order to provide incentive of reduced rates?
  - With what frequency would teens have to submit information to insurance companies for optimum effectiveness?
  - What are some initial ideas on the structure of an insurance-based incentive?
  - What are some potential long term incentives/discounts for installing a TDERC?

What are the key research needs, methodologies, and Federal role?

- Research objectives, tools, and methods
  - Review and modify program objectives
  - What are the research questions in relation to the objectives?
  - What are the available research tools and methods for developing the TDERC? Are there tools that would need to be developed?
  - What is the best method to obtain appropriate teen research subjects?
- System design and evaluation
  - What measures and protocols should be used to evaluate system effectiveness?
  - What is the best media in which to deliver data to teens, parents, and other authorities as applicable?
  - For how long should teens use a TDERC? Should the system adapt to the changing crash scenarios?
- Safety program implementation and evaluation
  - Which groups should receive the benefit of the TDERC?
  - What other behaviors and circumstances should be considered with the TDERC data and in what capacity (e.g., driving violations, incidents, etc.)?
  - Who pays, and how?

Additional questions from all attendees

Closing Remarks (4:20 p.m. – 4:30 p.m.)

A3. Teenage Drivers: Stats Sheet

Teenage Drivers: Stats Sheet

According to "Fatalities in Crashes Involving Young (15-20) Drivers by State,"[1] in 2003:

- Teen drivers (ages 15-20) were involved in crashes that resulted in 8,666 fatalities.

Role in crash	Number of fatalities	Percentage of fatalities
Teen drivers	3,657	42
Passengers of vehicles with teen drivers	2,384	28
Occupants of other vehicles	1,979	23
Non-occupants	646	7

Table 1. Passenger Vehicle Deaths by Role in Crash, Number and Percentage of Fatalities for 2003

Additional insight to the teen driving issue:

- The top three causes of deaths for teens (16-20 years old) are as follows for 2001: motor vehicle crashes (5,979 deaths), homicide (2,414 deaths), and suicide (1,879 deaths) .[1]
- Per Table 2 below, approximately 60 percent of 16- to 19-year-olds killed in traffic crashes were driving.[2]

Age	Drivers	Passengers
16	485	430
17	641	438
18	785	495
19	817	413
Total	2,728	1,776

Table 2. Passenger Vehicle Deaths by Age and Seating Position, 2002

According to "Beginning Teenage Drivers"[3]:

- The leading characteristics of fatal teen crashes are as follows:

Driver Age:	16	17-19	20-49
Driver error	85	78	66
Speeding	37	34	24
Single vehicle	50	46	40
3+ occupants	27	24	18
Drivers killed with 0.10+ BAC	11	22	43

Figure 1. Percentage of Fatal Crashes by Characteristic in 2002

[1] Subramanian, R. (2003). "Motor Vehicle Traffic Crashes as Leading Cause of Death in the United States, 2001." DOT HS 809 695.
[2] Insurance Institute for Highway Safety. "Fatality Facts: Teenagers, 2002." Available at www.iihs.org/safety_facts/fatality_facts/teens.htm.
[3] National Highway Traffic Safety Administration, Insurance Institute for Highway Safety (2003). "Beginning Teenage Drivers." Available at www.iihs.org.

Concerning safety belt use

- Two-thirds of teens killed in traffic crashes were not wearing their safety belts.[4]
- An observational study was conducted to investigate safety belt use on the way to school in the morning.[5] The study occurred at 12 high schools in Connecticut and Massachusetts. The rates observed are included in Table 3 below. Furthermore, in 23 percent of observations the adult driver was belted but the teenager was not.

	Males	Females
Adult driver	63	71
Teen passenger with adult driver	50	56
Teen driver	54	70
Teen passenger with teen driver	42	52

Table 3. Observed Safety Belt Use for Teen and Adult Drivers and Passengers

Specific risks for teenage drivers

- Two clearly identified high-risk conditions include nighttime driving and transporting young passengers.[6] The presence of one passenger almost doubled the fatal crash risk; two or more passengers increased the crash risk five-fold.[7]
- Distraction and increased risk-taking are contributors to the increased risk with transporting passengers.[8]
- Another study found a passenger gender effect that was stronger than the driver gender effect.[9] As shown in Table 4 below, both male and female teen drivers show more risky driving with male passengers than with female passengers.

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[4] National Highway Traffic Safety Administration (2003). "Safety Belts and Teens. 2003 Report." Available at www.nhtsa.dot.gov.

[5] Insurance Institute for Highway Safety (2002). Status Report, Vol. 37, No. 6. Available at www.iihs.org.

[6] Foss, R. and Goodwin, A. (2003). "Enhancing the effectiveness of graduated driver licensing legislation," Journal of Safety Research, 34, 79-84.

[7] Doherty, S.T.; Andrey, J.C.; and MacGregor, C. (1998). The situational risks of young drivers: the influence of passengers, time of day, and day of week on accident rates. Accident Analysis and Prevention, 30, 45-52.

[8] Williams, A.F. (2001). Teenage Passengers in Motor Vehicle Crashes: A Summary of Current Research. Available at www.iihs.org.

[9] Lerner, N., Singer, J. and Masseth, S. Pilot Assessment of Young Driver Distraction: Teen Driver Observational Study. Final report submitted to National Institute of Child Health and Human Development.

Driver/Passenger Group	% showing risky behavior
General Traffic	9.6
Teen Drivers	
Teen Male Driver	14.9
Teen Female Driver	13.1
No Passenger	14.4
Teen Male Passenger	18.7
Teen Female Passenger	11.1
Teen Male Driver, No Passenger	16.8
Teen Male Driver, Male Passenger	21.7
Teen Male Driver, Female Passenger	5.5
Teen Female Driver, No Passenger	12.0
Teen Female Driver, Male Passenger	12.9
Teen Female Driver, Female Passenger	15.5

Table 4. The Percentage of Vehicles Observed Exhibiting High Speed and/or Short Headway, for Various Driver and Passenger Groups.

- Various research efforts have found that young drivers perceive the following activities as less risky than older drivers: tailgating, driving in darkness, curves, inclines/declines, urban environments, bald tires, slow drivers on the road, wet roads, speeding, and drinking and driving.[10]
- Per Figure 2 below, teens are most vulnerable to crashes in the first 500 miles, with the first 250 miles having a crash involvement rate of 3.2 (per 10,000 miles), the next 250 miles having a rate of 1.3 (per 10,000 miles).[11]

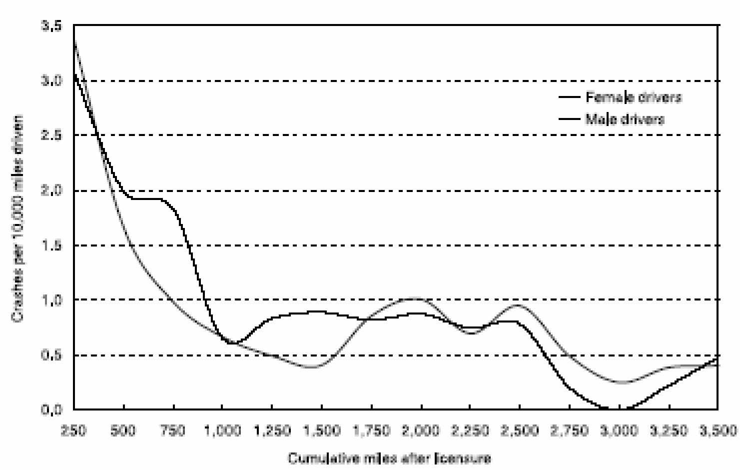

Figure 2. Crash Rate by Cumulative Miles Driven After Licensure and Gender

- For novice drivers, crash rates decrease dramatically from the 1st to the 7th month (41%), then gradually decrease through the 24th month after licensing (60% overall reduction).[12]

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[10] Eby, D.W and Molnar, L.J. (1998). Matching Traffic Safety Strategies to Youth Characteristics: A literature of Cognitive Development. DOT HS 808 927.
[11] McCartt A.T.; Shabanova V.I.; Leaf W.A. (2003). "Driving experience, crashes and traffic citations of teenage beginning drivers," Accident Analysis and Prevention, 35, (3), pp. 311-320
[12] Mayhew, D.R., Simpson, H.M. and Pak, A. (2003). "Changes in collision rates among novice drivers during the first months of driving." Accident Analysis and Prevention, 35, pp. 683-691.

Concerning graduated licensing:[13]

- Three Stages of Graduated Licensing: learner's permit, intermediate (or provisional, junior) license, and full (or unrestricted) license
- Graduated license programs have been found to be effective in three state evaluations
    - CA: 5.3-percent reduction in crashes (ages 15-17)
    - MD: 5-percent reduction in crashes, 10-percent reduction in daytime violations (ages 16-17)
    - OR: 16-percent reduction in crashes (male drivers, ages 16-17)

Weaknesses in some graduated licensing programs:[14]

- Employ weak restrictions (e.g., time permitted to drive, passenger restrictions)
- Not structured for "most useful learning experience for beginning drivers," including amount and type of driving experience
- Weak enforcement of restrictions

Parental management

- Simons-Morton and Hartos [15] summarized a large body of research on parental monitoring, and some of the data cited/conclusions include:
    - Parents have a mismatch between their perceived and the real risk, e.g., 61 percent thought it was risky to drive without wearing a belt, and 28 percent thought it was risky to drive with two or more teens in the vehicle
    - Low parental monitoring resulted in more crashes, high-risk behaviors, and violations
    - GDL does increase parental restrictions in some cases, including restricting driving times, number of passengers, etc.
- There is a general lack of data on current parenting behaviors, specifically attitudes towards limitations, motivations for implementing/enforcing limitations, knowledge of teen traffic injury risk, etc.

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[13] National Highway Traffic Safety Administration. "Saving Teenage Lives." Available at www.nhtsa.dot.gov.

[14] Foss, R. and Goodwin, A. (2003). "Enhancing the effectiveness of graduated driver licensing legislation," Journal of Safety Research, 34, 79-84.

[15] Simons-Morton, B.G. and Hartos, J.L. (2003). "How well do parents manage young driver crash risks?" Journal of Safety Research, 34, 91-97.

A4. Electronic Copilot for Teen Drivers Proposal

A Proposal for Developing a Teenage Driver Electronic Report Card

Background

Traffic crashes are the number one killer of today's teens.[16] In fact, teen drivers and occupants have the highest crash rate of any group. In 2002, 3,827 teens were killed and another 324,000 were injured in traffic crashes. Teens are especially at risk due to a combination of inexperience, immaturity, and unsafe driving practices. Key factors that underlie this risk are speeding, low use of safety belts (two-thirds of teens killed were not wearing safety belts [17]), alcohol use (24 percent of teen drivers killed in vehicle crashes were intoxicated [18]), driving at night, and transporting teenage passengers.[19]

Traditional traffic safety initiatives (e.g., licensing, enforcement, and education) continue to produce benefits, but achieving even greater reductions in fatalities and injuries may require innovative new approaches to further increase safe driving practices. One promising approach to encourage teen drivers to modify their unsafe actions is to use advanced vehicle-based technologies that are able to operate in real time to sense, transmit, record, and present information on unsafe driving behaviors. These technologies can be integrated into a safety device that functions as a "Teenage Driver Electronic Report Card" (TDERC) on safe behaviors. This electronic report card would function as a learning tool and motivator to help teens identify and improve their unsafe actions. Another possible application of the information is to determine an individual driver's eligibility for advancement through the different levels of graduated licensing programs. Finally, the safety information could be provided to insurance companies, which could further reward and motivate safe driving by providing monetary incentives based on objective reports from the TDERC.

Currently, some monitoring systems for teens are available for aftermarket installation. However, these technologies have not been formally evaluated; therefore their impact on safety is unknown. Furthermore, these devices are not designed for integration into education, licensing, enforcement, and insurance programs.

Numerous vehicle-based technologies can play a role in encouraging safer driver behavior. Technologies can include global positioning systems, eye glance monitoring, smart cards, biometrics, wireless communications, sensors (for vehicle kinematics, occupant position, belt use, presence of alcohol, etc.), and electronic data recorders. Technology decisions will be guided by their costs, adaptability as aftermarket options, safety-relevant behaviors to monitor, and the state-of-the-art.

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[16] National Center for Statistics and Analysis (2003). Traffic Safety Facts 2002, Young Drivers. DOT HS 809 619.
[17] National Highway Traffic Safety Administration (2003). "Safety Belts and Teens. 2003 Report." Available at www.nhtsa.dot.gov.
[18] National Center for Statistics and Analysis (2003). Traffic Safety Facts 2002, Young Drivers. DOT HS 809 619.
[19] Williams, A.F. (2001). Teenage Passengers in Motor Vehicle Crashes: A Summary of Current Research. Available at www.iihs.org.

Concept

The concept of the teen driving electronic report card is to monitor driver safety behaviors in real time, convey safety status information to the driver, and create a record of the information for possible use by other people or organizations to help reinforce safe behaviors. Developing a TDERC into an effective crash countermeasure will thus require research to determine which behaviors should be monitored to increase safety and what vehicle-based technologies are needed to monitor, display, and record safety information; Research will also be required to determine the most effective and acceptable approaches for using that information to modify teen driver behavior.

Figure 1 below illustrates one possible configuration of a TDERC. Notice the level of intervention in part relies on the driver's response to the feedback – if the driver modifies his or her behavior, the system will not take any further actions.

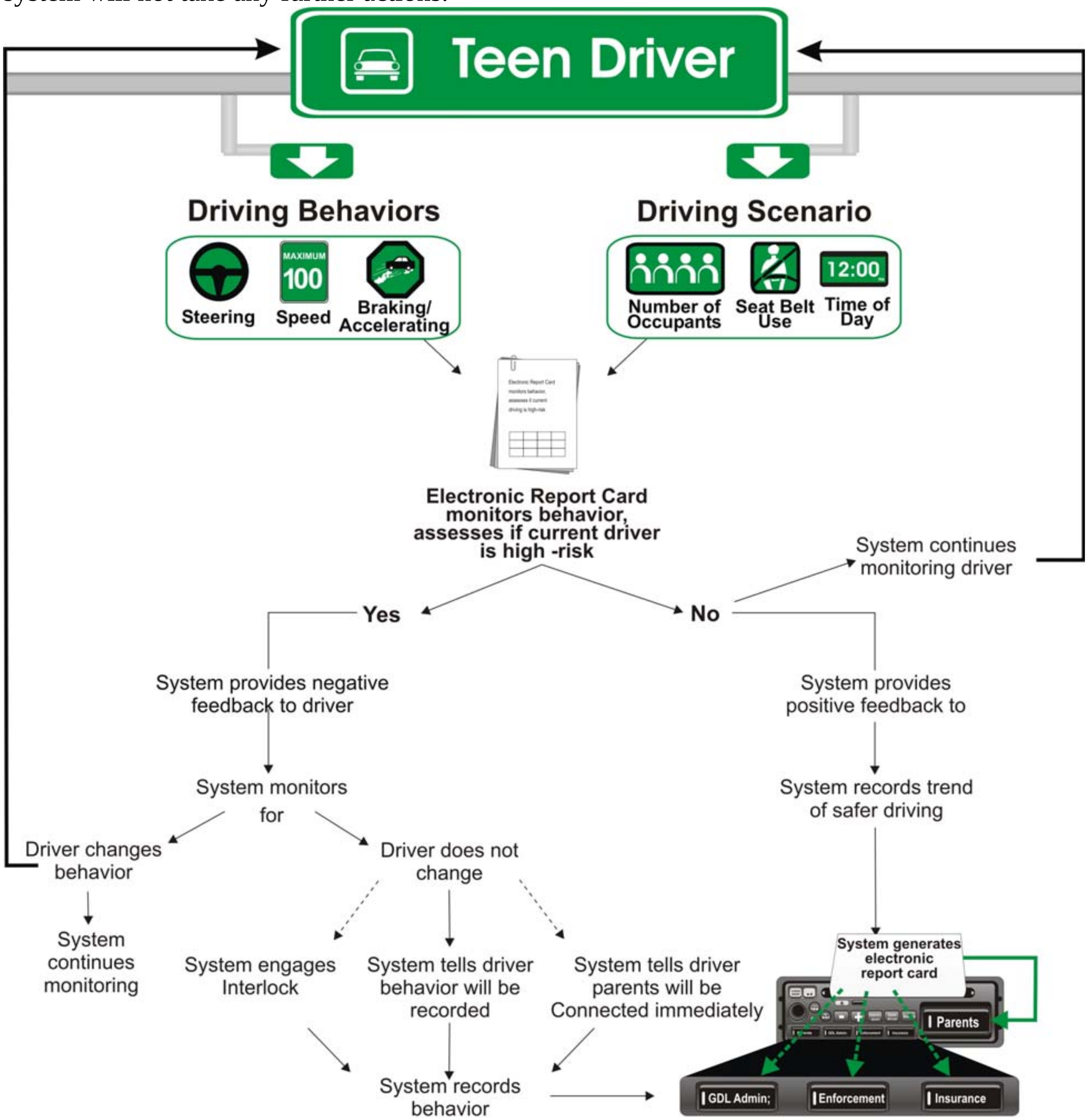

Figure 1. Conceptual Depiction of the Electronic Report Card

Several implementation options are conceivable, including:

- Use as part of driver education program.
- Use after driver education to reinforce safe driving behaviors during first years of driving.
- Providing data to parents to help monitor driving behaviors.
- Directly preventing unsafe behaviors through vehicle interlocks.
- Installation in vehicles of teens receiving tickets for traffic law violations or involved in crashes.
- Insurance reductions for teens demonstrating safe behaviors.
- Providing objective monitoring of requirements in current graduated driver licensing programs (e.g., night driving restrictions, passenger restrictions), as well as incorporation in enhanced graduated licensing programs that might expand driving privileges based on teen drivers' adherence to other safe behaviors as recorded in a TDERC.

Due to the current and recent advancements in vehicle technologies, many monitoring opportunities exist. Deciding on what to monitor as part of a TDERC will require that each option be assessed along many dimensions. Tables 1 and 2 provide examples of some potentially important behavioral measures, evaluation factors, and preliminary subjective evaluations of the measures. The evaluation factors listed in the tables are:

- Sensor feasibility: This column describes the current or near-term state of sensors for the behavior. Feasibility ranges from low (not readily available) to high (available now in vehicles).
- High priority – parent: This column indicated which behaviors are seen as high risk by parents, as reported by various researchers.
- Low acceptability – teen: This column represents which behaviors teens would be less accepting of being monitored as reported by various researchers and other articles.
- Estimated cost: Rated low to high, this column indicates the relative cost of adding this feature to the TDERC.
- Special support considerations: Some of the behaviors listed would require additional information from external sources (e.g., infrastructure) or require the integration of data from multiple in-vehicle sensors. This column indicates that requirement.
- Potential safety benefits: This column represents whether the expected safety benefits might be low, medium, high, or unknown in terms of the safety problem addressed and potential ability to change the specific behavior, given what we currently know
- Overall priority: This column identifies the relative priority to include the specific monitoring system in the first generation TDERC.
- Countermeasure: Based on the key below, the proposed level of feedback is indicated for each measure:
    1 - Immediate feedback, parental notification if vehicle is not immediately changed/vehicle put in motion and, if appropriate, interlock engagement
    2 - Immediate feedback, parental notification if continued
    3 - Immediate feedback, data recorded for TDERC report if continued
    4 - Feedback when vehicle not in motion, data recorded for TDERC report if continued
    5 - Feedback at end of trip, data recorded for TDERC report
    6 - Data recorded, no feedback
- Training potential - driving skills: This column indicates whether the particular monitoring and feedback, through exposure, is expected to improve driving skills.

- Training potential - decision making: This column indicates whether the particular monitoring and feedback, through exposure, is expected to improve decision-making skills.

Table 1 lists some potential vehicle control behaviors that could be monitored. Table 2 lists some potential driving practices that could be monitored.

Goal

The goal of this program is to develop and evaluate the effectiveness and acceptability of a vehicle-based Teenage Driver Electronic Report Card system that reduces crashes by accelerating the learning curve and safety consciousness of teenagers. To accomplish this goal, the program will determine device design requirements as well as assess the feasibility of and requirements for various implementation options.

During the first year, the goal will be to identify requirements for an effective and acceptable TDERC along with plans for a large-scale evaluation. If the concept and plan look promising, a three year, large-scale evaluation of the system in one or more communities will be initiated.

Vehicle Control Behavior	Sensor feasibility	High priority - parent	Low acceptability - teen	Cost	Special support considerations	Potential safety benefits	Priority	Counter-measure	Training potential - driving skills	Training potential - decision making
Speeding – threshold	High		X	Low		High	High	1		X
Speeding - speed limit	Low		X	High	Requires detailed infrastructure maps	High	Mid	2	X	X
Rapid accelerating	High			Low		Mid	Mid	4	X	
Rapid or erratic decelerating/ braking	High			Low		Unknown	Mid	4	X	
High lateral acceleration	High			Low		Mid	Mid	4	X	
Unsafe braking	High			Medium	Requires synthesis of data from other sensors	Unknown	Low	3	X	
Deviating from lane	Medium			High		High	Mid	3	X	
Correcting steering errors appropriately	Mid			Mid	Requires synthesis of data from other sensors	Mid	Mid	2	X	
Approaching curves too fast	Low			High	Requires synthesis of data from other sensors	Mid	Low	2	X	

Table 1: Possible Vehicle Control Behaviors That Could be Monitored in a TDERC

Driving Practices	Sensor feasibility	High priority - parent	Low acceptability - teen	Cost	Special support considerations	Potential safety benefits	Priority	Counter-measure	Training potential - driving skills	Training potential - decision making
Driving outside of permissible area	High			Low		Unknown	Mid	6		X
Driver not wearing belt	High	X		Low		High	High	1		X
Passenger not wearing belt	Medium	X		Medium-high	Requires rear-passenger sensors	High	High	1		X
Driving past curfew	High	X		Low		High	High	1, 6		X
Driving while impaired by alcohol as measured by a passive sensor	Low	X		High	Requires synthesis of data from other sensors	Mid	Low	1		X
Driving while impaired by alcohol as measured by a biometric sensor	Low	X		High	Requires synthesis of data from other sensors	Mid	Low	1		X
Driving when fatigued	Medium			High	Requires synthesis of data from other sensors	High	Mid	1		X
Transporting too many passengers	Medium	X		Medium-high	Requires rear-passenger sensors	High	High	1, 5		X
Tailgating	Medium			Medium-high		Unknown	Mid	3		X
Driving while distracted	Medium		X	High	Requires synthesis of data from other sensors	Unknown	Mid	2		X
Driving with radio at distracting/unsafe volume	Medium	X	X	High	Requires synthesis of data from other sensors	Mid	Mid	2		X

Table 2: Possible Driving Practices That Could Be Monitored in a TDERC

Appendix B: List of Participants

Jeffrey Arnett
Independent Scholar

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Virginia Commonwealth University

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Director
Virginia Tech Transportation Institute

Max Donath
Director, ITS Institute
Center for Transportation Studies
University of Minnesota

Terry Kline
Associate Professor, Loss Prevention & Safety
Eastern Kentucky University

Neil Lerner
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WESTAT

Gary Lewis
Collision Reconstruction Unit
Montgomery County Department of Police

James McKnight
Transportation Research Associates

David Preusser
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Allen Robinson
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Highway Safety Center
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Matt Smith
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DELPHI

Stephen Talpins
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University of Minnesota

Allan F. Williams
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Stephanie Binder
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Duane A. Perrin
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Division
National Highway Traffic Safety Administration

Raymond Resendes
IVI Program Manager
ITS Joint Program Office

Jim Wright
Highway Safety Specialist
National Highway Traffic Safety Administration

Appendix C: Michael Perel's Presentation

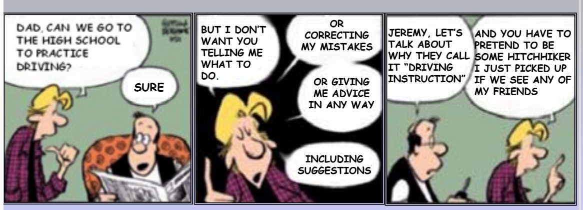
Perel Slide 1.

Teen Driver
Electronic Report Card
Workshop
Nov 4, 2004

Technical Manager: Mike Perel,
NHTSA, Office of Vehicle Safety Research
Program Coordinator: Ray Resendes,
Federal Highway Administration
Joint Program Office

Perel Slide 2.

Where do we start?



Perel Slide 3.

Perel Slide 4.

16 year old female driver

17 year old passenger

V1 was negotiating a left hand curve and departed the right side of the road, glancing off bushes and striking 40 cm tree with front.

The driver and passenger reported no injuries on scene.

The weather was clear, the roadway was dry and it was daylight at the time of the crash.

Perel Slide 5.

Lots of Statistics Define the Crash Problem

- **Leading cause of death for 16-19 year olds**
- **Over 3,620,000 teens in crashes**
- **Fatality rate per miles driven for 16-year-old male drivers is over three times that of 19-year-old males**
- **46% of 16-17 year old drivers are in crashes**
- **45% of teen drivers in fatal crashes were 16-17**
- **About 66% of teens killed in crashes not wearing belts**

Perel Slide 6.

How can problem be solved?

- **Licensing**
- **Enforcement**
- **Education**
- **Parental involvement**
- **Behavioral modification using in-vehicle monitoring and feedback**

Perel Slide 7.

Data collected from in-vehicle monitoring could be used to:

- Provide an "electronic report card" using vehicle-based technologies that are able to sense, record, analyze, and present information on unsafe driving behaviors
- Prevent unsafe driving (belt use required)
- Provide information to parents and driving instructors
- Assure adherence to graduated driver's licensing program and expand requirements
- Allow insurance incentives for safe driving behaviors

Perel Slide 8.

Why this might work?

- Unsafe behaviors contribute to teen crash problem
- Other applications of behavior-based safety have proven effective
  - Reducing risky behaviors will reduce actual crashes and injuries
- Technology advancing rapidly
- Could be integrated into existing safety programs for 16-17 year olds
- Parents need help

Perel Slide 9.

Why this might not work?

- Device costs and usability
- Privacy concerns
  - Acceptability to teens and parents
- Implementation challenges that involve many stakeholders
- Difficulty of doing appropriate developmental and evaluation research to quantify benefits

Perel Slide 10.

Key Research Topics

- What behaviors to record?
- Human factors considerations for system development?
- How to deploy a TDERC?

Effectiveness, Acceptance, Feasibility

Perel Slide 11.

Workshop Background

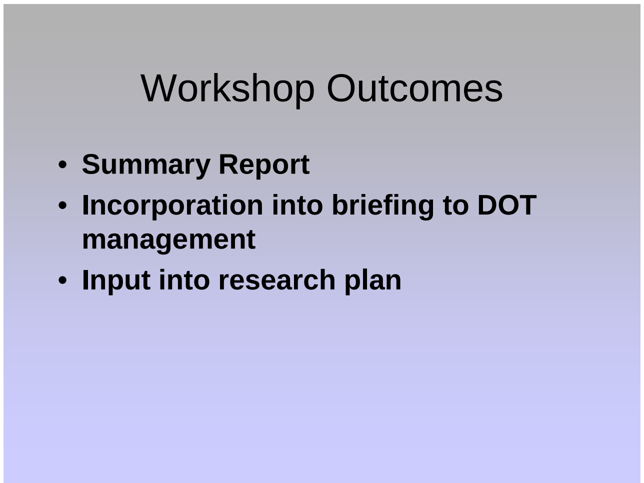
- DOT is funding several major Intelligent Transportation Systems safety initiatives
- TDERC being proposed as possible new initiative
- Workshop is one step in decision process

Perel Slide 12.

Workshop Objectives

- Identify viewpoints of stakeholders and researchers on viability of proposed initiative
  - The degree to which the teen crash problem can be addressed by a TDERC
  - Is TDERC technically feasible?
  - How can it be deployed in the real world? What is the role of private sector and public institutions?
  - What should be the Federal role?
  - Factors influencing effectiveness, acceptance, and feasibility
  - Research needs and methods
    - Consider Generation I and II systems

Perel Slide 13.



Perel Slide 14.

Appendix D: James McKnight's Presentation (text only)

McKnight Slide 1.

Teen Driver Electronic Report Card (TDERC) Workshop

Behaviors Leading to Teen Crashes

McKnight Slide 2.

TEEN CRASHES

Per mile rate of new drivers

Ten times that of experienced adults

Drops by two-thirds in first 1,000 miles

Primarily the result of inexperience

Teen Driver Electronic Report Card (TDERC) Workshop

McKnight Slide 3.

TEEN CRASHES

SEVERITY

Fatal	.5%
Injury	32.7%
PDO	66.7%

Teen Driver Electronic Report Card (TDERC) Workshop

McKnight Slide 4.

TEEN CRASHES

STUDY OF TEEN DRIVER ERRORS

Police reports of 2100 non-fatal crashes
Analyzed narratives for errors
Tabulated frequencies by behavior

Study sample

Experience: First Year, Third year (r = .96)
States: California and Maryland (r=.89)
Male and Female (r=.95)

McKnight Slide 5.

SEARCH AHEAD 19.1%

Distance	3.1%
Roadsides	4.3%
Before left turns	4.8%
The car ahead	3.1%
Left-turning vehicle	2.9%
Other	0.9%

McKnight Slide 6.

SEARCH TO THE SIDE 14.2%

Intersection: burdened	7.7%
Intersection: privileged	5.5%
Sight obstructed	0.8%
Other	0.2

McKnight Slide 7.

SEARCH TO THE REAR	9.4%
Slowing	3.0%
Backing	2.1%
Periodically	2.1%
Changing lanes	1.5%
Other	0.7%

McKnight Slide 10.

MAINTAINING SPACE	9.8%
Following distance	5.8%
Crossing and entering	1.4%
Side clearance	1.3%
Overtaking	1.1%
Other	0.2%

McKnight Slide 8.

ATTENTION	23.0%
Maintaining attention	18.6%
Avoiding distractions	3.8%
Attention sharing	0.7%

McKnight Slide 11.

EMERGENCIES	9.4%
Swerving	5.6%
Skid recovery	1.4%
Quick braking	1.0%
Brake failure	0.7%

McKnight Slide 9.

ADJUSTING SPEED	20.8%
Traffic/road conditions	8.7%
Curves	6.1%
Slick surfaces	2.3%
High speed	0.7
Other	1.5%

McKnight Slide 12.

BASIC CONTROL	8.0%
Lane Keeping	2.6%
Turning Path	1.3%
Braking	1.3%
Turning Speed	0.7%
Other	2.1%

McKnight Slide 13.

DRIVER - VEHICLE	6.3%
Alcohol Impairment	2.4%
Fatigue	1.7%
Vehicle	1.5%
Other	0.7%

McKnight Slide 16.

Teen Driver Electronic Report Card (TDERC) Workshop

Teen Driver Crashes:

- **Caused by mistakes**
- **Result of inexperience**
- **Don't recognize danger**

McKnight Slide 14.

TRAFFIC CONTROLS	5.6%
Traffic lights	1.7%
Stop signs	1.3%
Lane use	1.5%
Passing	0.6%
Other	0.7%

McKnight Slide 17.

Teen Driver Electronic Report Card (TDERC) Workshop

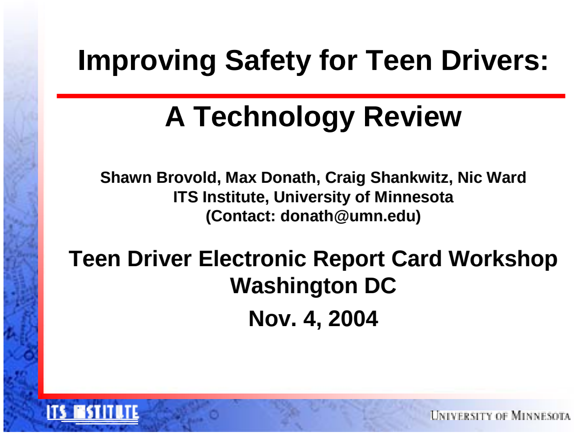
????????????

McKnight Slide 15.

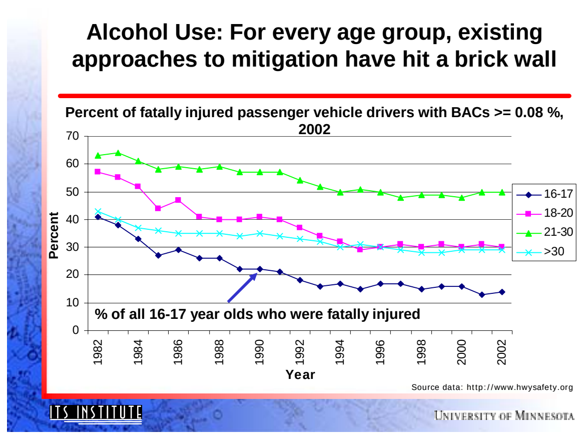
SIGNALS	1.2%
Interpreting signals	0.8%
Signaling intent	0.3%
Signaling presence	0.1%

Appendix E: Max Donath's Presentation

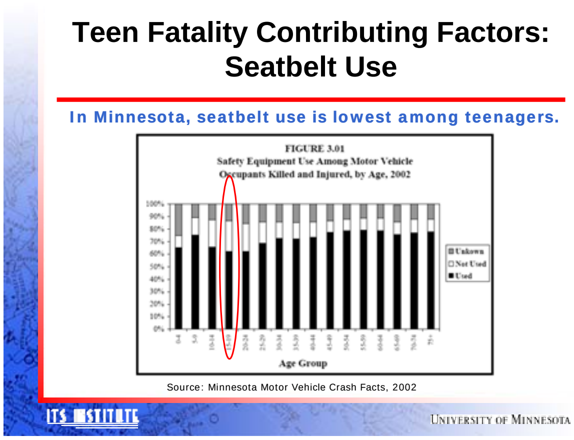
Donath Slide 1.



Donath Slide 4.



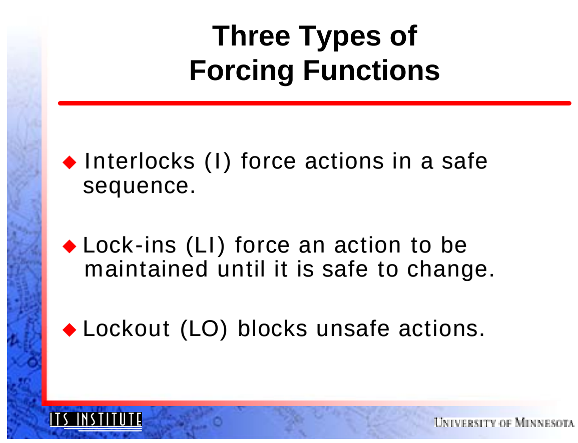
Donath Slide 2.



Donath Slide 5.

Donath Slide 3.

Donath Slide 6.



Donath Slide 7.

Forcing Behavior: Interventions

Intelligent Speed Adaptation (ISA)

Prevents driver from exceeding road's posted limit. Achieved through combination of Global Positioning System (GPS) and digital road map. In some systems, speed is limited by link with elements of vehicle's power train, such as throttle or fuel system. (LO)

Seatbelt interlock

Requires all occupants to engage seatbelt prior to starting vehicle. (I)

Alcohol interlock

Prevents teen driver from starting vehicle if alcohol is detected. (I)

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Donath Slide 8.

ISA Summary

- Three types of ISA systems:
  - Advisory – in vehicle warning, driver ultimately limits speed.
  - Mandatory – active control, vehicle limits speed, overrides driver.
  - Voluntary – advisory with option of mandatory.
- Three notification levels possible:
  - Fixed – posted speed limit only.
  - Variable – site specific limits, ex: construction zones, school zones, curves.
  - Dynamic – limits based on hazard potential, e.g. weather, time of day, traffic congestion, pavement condition.

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Donath Slide 9.

ISA Summary

- Location
  - ISA has been evaluated in simulation and field studies in Australia and several European countries including, Belgium, France, Germany, England, Netherlands, and Sweden.
- Observations
  - In general, these projects have shown consistent reductions in speed levels, better awareness of speed limits, and improved compliance with speed limits (Besseling, 2003; Carsten & Fowkes, 2000; Vagverket, 2003).
- Impact
  - It has been estimated that speed control systems such as ISA have the potential for achieving almost 60% fatality reduction (Carsten & Fowkes, 2000).

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Donath Slide 10.

"Car computer to stop you speeding" from The Times, July 1, 2004

- The Government to establish national speed limits database … pave way for all cars to be fitted with devices that prevent speeding.
- The digital speed map of Britain … essential 1st step towards introducing ISA, … automatically applies brakes or blocks accel.
- On-board computer linked to satellite positioning system will use digital map to identify local speed limit. If drivers attempt to exceed limit, they hear series of bleeps and accelerator pedal starts vibrating.
- Ministers have not ruled out eventually making some version of system compulsory ….
- …but no central speed limits database for whole country, and many local authorities have poor records of limits on their roads.
- The DfT believes the absence of a national database is hampering development of ISA.
- A DfT spokesman said: "If the whole country was mapped, it might make it more logical and practical for manufacturers to consider offering ISA. There could well be road safety benefits from ISA."

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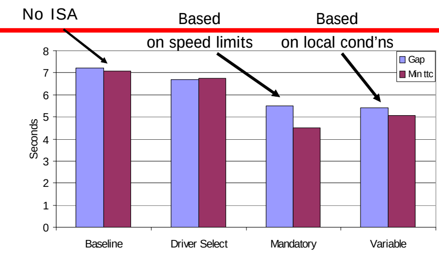
Donath Slide 11.

ISA: Compensation for "Lost Time"



When drivers have speed restricted by a mandatory or variable system, there may be a tendency for them to compensate by accepting shorter gaps in crossing traffic and closer following distances in traffic compared to baseline driving (or only an advisory system). This is believed to result from a perceived need to make up for limited mobility and time.

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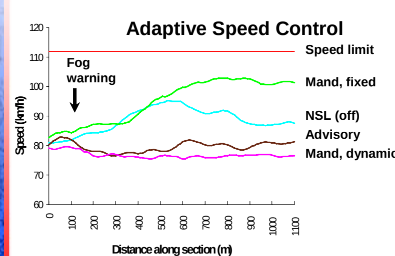
Donath Slide 12.

ISA: Complacency

We relax our responsibility and let the system take over



In expt, subjects drove a simulator in traffic conditions with heavy fog. Note that drivers drove at a speed lower than the speed limit with no speed control, and in response to the advisory and dynamic system. However, drivers with the mandatory system seemed to be complacent and drive to the system limit rather than use their own judgment to slow down. As a result, drivers tended to drive toward the speed limit even though conditions suggest a lower speed to be safe.

(courtesy of O. Carsten, ITS, Leeds)

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Donath Slide 13.

Alcohol Interlock Options

- **Purchase/Lease**
  - Expensive (?): $795 or $60/mo.
  - Records data log of tests, and rolling retests.
  - Interlock tolerance level can be changed.
  - Installed by certified dealer.

ADS Determinator Interlock

- **Manufacture**
  - Based on personal BAC technology.
  - Zero tolerance threshold hardwired.
  - Uses low cost sensor.
  - Integrate with system.

AlcAlert BT5500

$40

Donath Slide 14.

Modifying Behavior: Feedback

- Need context (static and dynamic)
- Auditory or other sensory signals triggered by unsafe vehicle operation
  - Excessive speed for local conditions, e.g. speeds incompatible with road curvature, can lead to lane departure.
  - "Hassles" driver until behavior is corrected.
- Prediction of road curvature can inform the driver of necessary upcoming maneuvers (especially useful in rural areas at night).
- Technology can monitor position within lane and provide feedback, but significant technology cost involved. Do we want to go there for teens?

Donath Slide 15.

Can Technology Predict/Prevent Lane Departure? Sense headway?

- Can detect/predict whether the vehicle is about to leave the road or lane
- Can use sensed lateral vehicle position to generate a steering wheel torque that helps driver stay in lane.
- Can monitor headway and provide feedback. Systems being deployed now.
- Can detect whether the driver is driving "inappropriately", has lost control.
- If driver does lose control (e.g. DWI), can implement aggressive intervention strategies.
  - Example: Automatically steer vehicle to shoulder and bring it to a safe stop. Demonstrated in Minnesota, 1997.

Donath Slide 16.

Reporting Behavior: Consequences Incentives, Reward and Punishment

- Record vehicle parameters such as speed, acceleration, braking, throttle use, distance, time of day.
- Parents can be notified in real-time of unsafe driving behavior. Parents can also inspect "report card" of data to review teen driving behavior offline.
- Review also possible by insurance (insurance premium, rebates), police (fines), DPS (license progression, awards).

Donath Slide 17.

Optional Enabling Technology

Smart Key

- Empowering technology - RFID/Smart Key.
- Enables the system to recognize who is driving so parents can opt out.
- Enables individual settings for parents of multiple teen drivers.

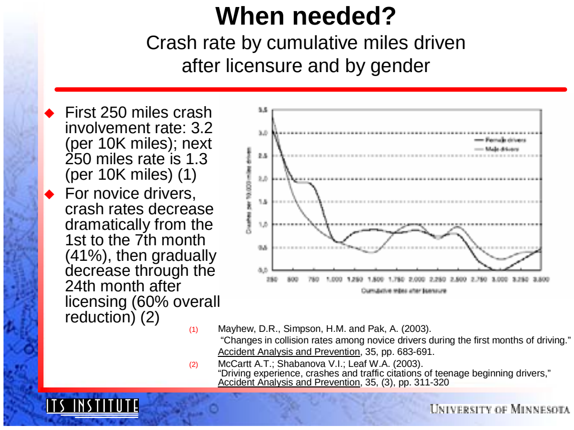
Donath Slide 18.

Design Opportunities

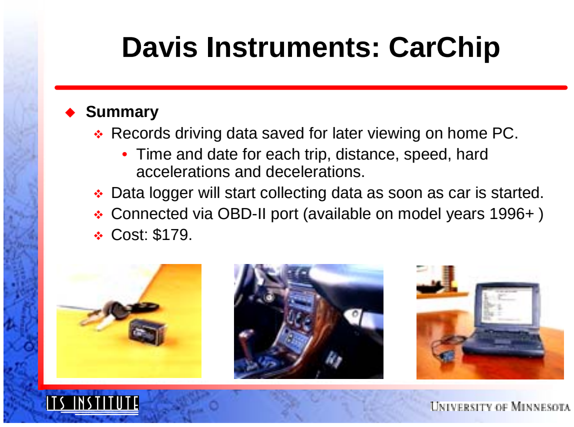
Indirectly

	Speed	Inexperience	Inattention/ Distraction	Alcohol	Seatbelts
Forcing	X			X	X
Feedback	X	X	X		
Reporting	X	X	X	X	X

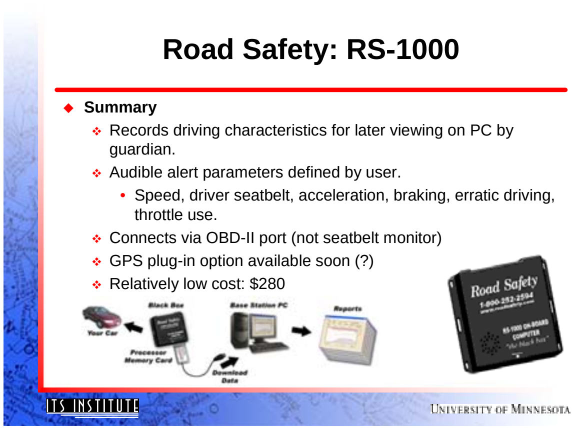
Donath Slide 19.



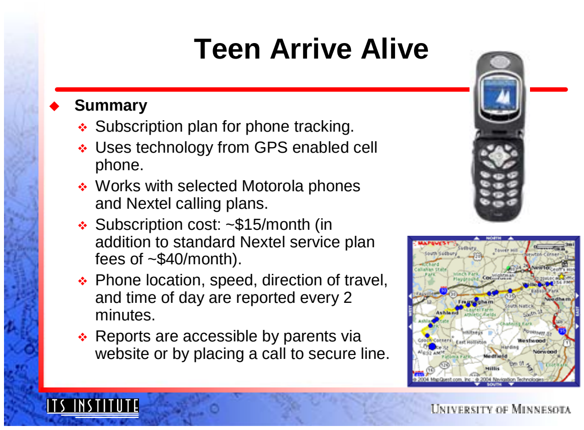
Donath Slide 20.



Donath Slide 21.



Donath Slide 22.



Donath Slide 23.

Existing teen driving aids

website	roadsafety.com	www.davisnet.com------------------->		signaltrac.com	networkcar.com	smart-driver.com	landairsea.com	teenarrivealive.com
Manufacturer	RoadSafety	Davis Instruments---------------->		SignalTrac	NetworkCar	SmartDriver	LandAirSea	TeenArriveAlive
Product	**RS-1000**	**CarChip E/X**	**DriveRight 600**	**SignalTrac**	**NetworkCar**	**SmartDriver**	**MobileWatch**	**TeenArriveAlive**
Base Price ($)	280	179	425	799	995	495	895	N
activation fee ($)	N	N	N	145	included	69	N	50
service fee ($/yr)	N	N	N	399/yr	108/yr	100/yr	520/yr	180/yr
Data Collected								
location (GPS)	*optional	N	Y	Y	Y	N	Y	Y
speed	Y	Y	Y	Y	N	Y	Y	Y
distance	Y	Y	Y	Y	N	Y	Y	Y
acceleration	Y	Y	Y	N	N	N	N	N
deceleration/braking	Y	Y	Y	N	N	N	N	N
lateral acceleration	Y	N	N	N	N	N	N	N
driver seatbelt use	optional	N	optional	optional	N	N	N	N
throttle position	Y	Y	N	N	N	Y	N	N
time of day	Y	Y	Y	Y	Y	Y	Y	Y
alcohol	N	N	N	N	N	N	N	N
smart key	N	N	N	N	N	N	N	N
unsafe backing	optional	N	N	N	N	N	N	N
Notification								
real-time GPS	*optional	N	N	Y	Y	N	Y	Y
in-vehicle display	N	N	Y	N	N	N	N	N
online reports	N	N	N	Y	Y	N	Y	N
e-mail alerts	N	N	N	Y	N	N	N	N
cellphone alerts	N	N	N	N	N	N	Y	Y
Additional Information	1,3		2,3	1	1		1	1

*feature is not yet available
(1) broadcasts via cellular connection
(2) LCD display on dashboard
(3) auditory feedback

DESIGN OPPORTUNITIES
FORCING
FEEDBACK
REPORTING

Donath Slide 24.

Existing system deficiencies

Also see www.gps-practice-and-fun.com/teen-car-tracking.html

- Current systems are too passive. None of the systems:
  - *Modify* speed threshold based on individual road's local speed limit, or upcoming road curvature (as per ISA), time of day or weather (RWIS).
  - *Force* behavior such as using seatbelt or maintaining sobriety.
  - *Recognize* current driver.
- Digital maps can be updated with speed limits; real-time wireless access for pavement condition, weather, congestion already available in Minnesota.
  - Minnesota: One point of contact for all statutory speed limits.
- Need teen driver-parent centric system, designed to modify dangerous teen driving behavior and empower parents.

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Donath Slide 25.

Driver Report Cards: The issue is not only "technology"

- What are the tests? The performance criteria?
  - Speed violation? Stability of accel/decel, headway? Lane wandering? Distraction measure?
- What thresholds does one set for pass/fail on each?
- How does one come up with an overall grade?
- Is this a continuous driving exam? What are the thresholds for moving from one level to the next?
- Does one exam (ie report card) fit every state? …every teen?
- Feedback mechanism? Incentive?

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Donath Slide 26.

Mechanisms of Unsafe Driving – Speeding: "Report Cards" cannot deal with all of these

- **1. Perception:**
  - Insufficient experience to accurately perceive speeds.
- **2. Recognition:**
  - Insufficient experience to recognize unsafe limits.
- **3. Skill:**
  - Insufficient experience to acquire adequate speed control skills.
- **4. Personality:**
  - Youth and personality (sensation seeking) may attract teen driver to thrill of risk taking and unsafe speed
- **5. Motivation:**
  - Absence of external factors to motivate ("enforce") safe speeds. Anonymity. Peer pressure motivates risky behavior.
- **6. Naivety:**
  - Absence of sufficient exposure to negative consequences of speed choice to "learn" risks of unsafe speeding; optimism bias

Donath Slide 27.

Mechanisms of Unsafe Driving – Speeding: Beyond "Report Cards"

Reporting	Feedback	Forcing
4, 5, 6	1, 2, 3, 6 (ISA)	3 (ISA)

- **1. Perception**
- **2. Recognition**
- **3. Skill**
- **4. Personality**
- **5. Motivation**
- **6. Naivety**

- **… and ignition interlocks to deal with impairment (which affect 1,2,3)**

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June 2006

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people saving people